Chapter 4: 4.3, 4.7, 4.13, 4.18, 4.22

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4.3

```
library(readxl)
cloth <- read_excel("cloth.xlsx")



clothLong=reshape(cloth,
                  varying = c("Bolt1", "Bolt2", "Bolt3",
                              "Bolt4", "Bolt5"),
                  v.names = "Yield", timevar = "Bolt",
                  direction = "long")
```

```
cloth.aov=aov(Yield ~ factor(Bolt) + factor(Chemical), data = clothLong)
summary(cloth.aov)
```

```
##                  Df Sum Sq Mean Sq F value   Pr(>F)
## factor(Bolt)      4 157.00   39.25  21.606 2.06e-05 ***
## factor(Chemical)  3  12.95    4.32   2.376    0.121
## Residuals        12  21.80    1.82
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
MSe=summary(cloth.aov)[[1]][3,3]
```

$H_0 : T_1 = ... = T = p = 0$

vs

$H_1 : T_i \neq 0$ at least one.

From our ANOVA we see that our chemical has an f-value of 2.376 with a p-value = 0.121. Our p-value is too big so we must fail to reject our null hypothesis and conclude that there is no differences between the treatment/chemical types.

4.7

```
library(readxl)
cscale <- read_excel("cscale.xlsx")

cscaleLong=reshape(cscale,
                  varying = c("Coupon1", "Coupon2", "Coupon3",
                              "Coupon4"),
                  v.names = "Yield", timevar = "Coupon",
                  direction = "long")
```

(a)

```r
cscale.aov=aov(Yield ~ factor(Coupon) + factor(Tip), data = cscaleLong)
summary(cscale.aov)
```

```
##                Df Sum Sq Mean Sq F value   Pr(>F)
## factor(Coupon)  3  0.825 0.27500   30.94 4.52e-05 ***
## factor(Tip)     3  0.385 0.12833   14.44 0.000871 ***
## Residuals       9  0.080 0.00889
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
MSe=summary(cscale.aov)[[1]][3,3]
```

$H_0 : T_1 = ... = T = p = 0$

vs

$H_1 : T_i \neq 0$ at least one.

Based on our ANOVA we see that we have a f-value of 14.44 and a p-value of 0.000871. Our p-value is very small compare to the significance value so we must reject our null hypothesis and conclude that the treatment/tips are significantly different.

(b)

```r
ybar.trt=as.vector(with(cscaleLong, tapply(Yield,Tip,function(x) mean(x)))) #bar(Y_i.) vector

#1-2
a=4;b=4;N=a*b;alpha=0.05
t0=(ybar.trt[1]-ybar.trt[2])/sqrt(2*MSe/b)
cri=qt(alpha/2,(a-1)*(b-1),lower.tail=F)
pvalue=2*pt(abs(t0),(a-1)*(b-1),lower.tail=F); pvalue
```

```
## [1] 0.7163449
```

```r
#1-3
a=4;b=4;N=a*b;alpha=0.05
t0=(ybar.trt[1]-ybar.trt[3])/sqrt(2*MSe/b)
cri=qt(alpha/2,(a-1)*(b-1),lower.tail=F)
pvalue=2*pt(abs(t0),(a-1)*(b-1),lower.tail=F); pvalue
```

```
## [1] 0.09354966
```

```r
#1-4
a=4;b=4;N=a*b;alpha=0.05
t0=(ybar.trt[1]-ybar.trt[4])/sqrt(2*MSe/b)
cri=qt(alpha/2,(a-1)*(b-1),lower.tail=F)
pvalue=2*pt(abs(t0),(a-1)*(b-1),lower.tail=F); pvalue
```

```
## [1] 0.001488949
```

```r
#2-3
a=4;b=4;N=a*b;alpha=0.05
t0=(ybar.trt[2]-ybar.trt[3])/sqrt(2*MSe/b)
cri=qt(alpha/2,(a-1)*(b-1),lower.tail=F)
pvalue=2*pt(abs(t0),(a-1)*(b-1),lower.tail=F); pvalue
```

```
## [1] 0.05100326
```

```r
#2-4
a=4;b=4;N=a*b;alpha=0.05
```

```
t0=(ybar.trt[2]-ybar.trt[4])/sqrt(2*MSe/b)
cri=qt(alpha/2,(a-1)*(b-1),lower.tail=F)
pvalue=2*pt(abs(t0),(a-1)*(b-1),lower.tail=F); pvalue
```

```
## [1] 0.002578639
```

```
#3-4
a=4;b=4;N=a*b;alpha=0.05
t0=(ybar.trt[3]-ybar.trt[4])/sqrt(2*MSe/b)
cri=qt(alpha/2,(a-1)*(b-1),lower.tail=F)
pvalue=2*pt(abs(t0),(a-1)*(b-1),lower.tail=F); pvalue
```

```
## [1] 0.0001290132
```

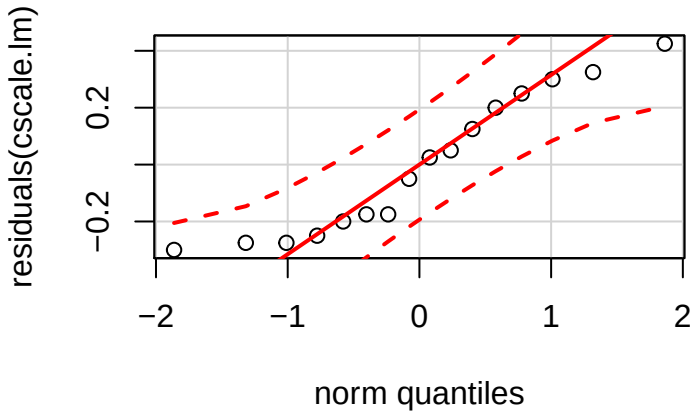
While using Fisher LSD we output a pvalue for the compariosns of $\mu_1 = \mu_2$, $\mu_1 = \mu_3$, $\mu_1 = \mu_4$, $\mu_2 = \mu_3$, $\mu_2 = \mu_4$, and $\mu_3 = \mu_4$ and the results are presented above respectively. We see that the comparisons of $\mu_1 = \mu_4$, $\mu_2 = \mu_4$, and $\mu_3 = \mu_4$ are different in tips of mean hardness.

(c)

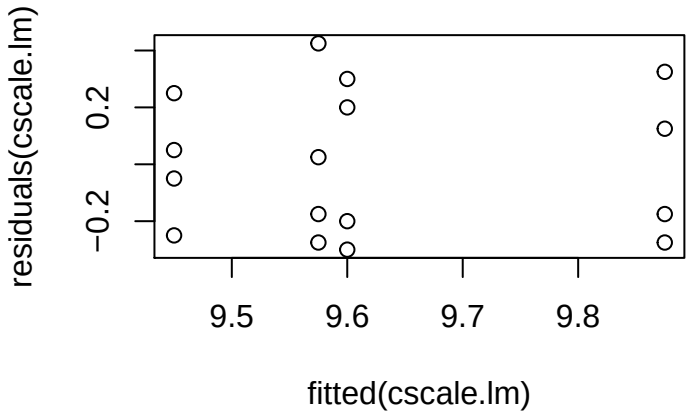
```
cscale.lm=lm(Yield ~ factor(Tip), data = cscaleLong)
summary(cscale.lm)
```

```
##
## Call:
## lm(formula = Yield ~ factor(Tip), data = cscaleLong)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.3000 -0.2125 -0.0125  0.2125  0.4250
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    9.5750     0.1373  69.732   <2e-16 ***
## factor(Tip)2   0.0250     0.1942   0.129    0.900
## factor(Tip)3  -0.1250     0.1942  -0.644    0.532
## factor(Tip)4   0.3000     0.1942   1.545    0.148
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.2746 on 12 degrees of freedom
## Multiple R-squared:  0.2984, Adjusted R-squared:  0.1231
## F-statistic: 1.702 on 3 and 12 DF,  p-value: 0.2196
```

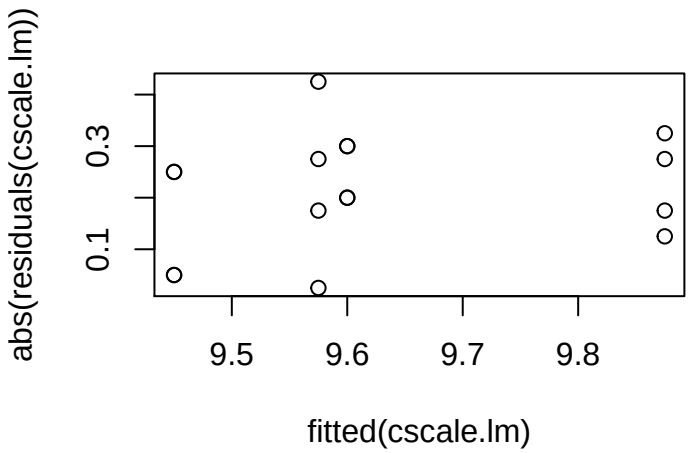
```
library(car)
qqPlot(residuals(cscale.lm))
```




```
plot(fitted(cscale.lm), residuals(cscale.lm))
```




```
plot(fitted(cscale.lm), abs(residuals(cscale.lm)))
```



After observing the qqplot and residual plot we see that normality is fine and there is no pattern but a structureless image on our plot. We can conclude our model is good.